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This publication gives information on new developments of interest to agriculture on laboratory and field investigations of the du Pont Company and its subsidiary companies.

In addition to reporting results of the investigations of the Company and its subsidiaries, published reports and direct contributions of investigators of agricultural experiment stations and other institutions are given dealing with the Company's products and other subjects of agricultural interest.

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Agricultural News Letter (du Pont)
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HYGROSCOPICITY OF MIXED FERTILIZERS INVESTIGATED AND NEW RAPID METHOD OF DETERMINATION DEVELOPED

EDITOR'S NOTE:- Dr. Keenen discusses here the development of "a rapid practical method by which the comparative moisture behavior of various fertilizers can be studied under controlled conditions." The subject is obviously of interest to manufacturers of fertilizers, investigators, agronomists, farmers and others. It is believed that the apparatus described will have uses for purposes other than that for which it was designed. The figures and diagram mentioned in the text and a photograph of the device will be found at the end of the paper.

By Frank G. Keenen, Research Chemist,
Ammonia Department,
E. I. du Pont de Nemours & Co., Inc.,
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The increasing commercial availability and decreasing costs of atmospheric nitrogen fixation products, such as urea, calcium and ammonium nitrates, ammoniating solutions, etc., have necessitated some modifications of fertilizer mixing operations in order to utilize the advantages offered by these new materials. Among the many chemical and physical properties affected, hygroscopicity or deliquescence is of particular interest. The demands imposed by mechanical distributors, increased plant food content with removal of absorbent fillers, and specific deliquescent nature of certain materials, all work together to create new problems in the maintenance of satisfactory physical condition in fertilizer mixtures.

The manufacturer and farmer are interested in just three things concerning moisture absorption: (1) does it take place under local conditions, (2) how fast in comparison with other familiar products, (3) what effect does the absorbed moisture have upon the physical properties of the mixture. A rapid practical method by which the comparative moisture absorption behavior of various fertilizers can be studied under controlled conditions has been developed.

Factors Affecting Occurrence of Hygroscopicity

A substance absorbs moisture when the humidity in the surrounding air exceeds the vapor pressure of its saturated solution at the existing temperature. The critical hygroscopicity usually expressed as the relative humidity at which a

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chemical compound begins to absorb moisture is a definite and unalterable physical characteristic just as its melting point, density or solubility.

Particularly important in fertilizer mixtures is the fact that combinations of materials have lower critical values, i.e. are more hygroscopic, than any of the components taken singly. The magnitude of this mutual effect seems unpredictable. Compounds having critical values around 60%-75% relative humidities may when mixed show critical values from 20%-50% relative humidities. Any given salt pair has a specific value of course, but too much emphasis cannot be placed upon the fact that it is the specific combination of ingredients more than particle size, ratios or properties of any single component which controls the critical hygroscopicity of a mixed fertilizer.

It logically follows that anything which tends to prevent contact between the components of a mixture may materially raise the initial critical hygroscopicity value. The two practical ways of doing this are: (1) keeping the free moisture content of the mixture low and (2) adding inert dusts or absorbent fillers. Such a stabilized dry mixture when exposed to rising humidities would begin to absorb moisture as soon as the critical value of some individual component was reached. The liquid phase thus formed would immediately wet and dissolve neighboring salts and the critical value would drop to that of the combined salts. This explains why a mixture remains seemingly satisfactory for a long time then suddenly becomes damp and stays damp. It is also one of the reasons, though not the only one, for the quicker absorption of moisture by a mixture which has been damp and dried out. Granulation of complete mixtures presents this latter case as each granule has in its surface an intimate combination of the most soluble salts present, however mixing granular components presents the opposite extreme and effectively prevents undesirable mutual action.

Factors Affecting Rate of Hygroscopicity

The moisture absorption rate is in many ways more important than the fact of its occurrence. Two factors control the rate: (1) the driving force, and (2) the area over which this force acts. In deliquescence the driving force is the differential between the existing relative humidity and the critical relative humidity for the specific mixture or compound under consideration.

The area factor is dependent upon (1) particle size, (2) protective effects of inert materials coating the surfaces of active components and (3) concentration of hygroscopic contact points in the heterogeneous surface of the mixture. The particle size has been found of much less significance than formerly assumed. Using the method described in this paper, urea crystals graded in several sizes between 14 mesh and 150 mesh showed no difference in hourly absorption rates at 75% or at 80% relative humidities. The average protective coating of inert dusts, although helpful in delaying the appearance of a liquid phase and avoiding caking on subsequent drying, loses its effect relatively. The solution formed at the few exposed points by the initial moisture absorbed spreads over the inert material and thus vitiates its influence.

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The concentration of active components in the mixture is more important than either of the former factors in average fertilizers, since it determines the number of hygroscopic points in each unit area of exposed material. Absorption of moisture takes place first at the contact points where the contacting salts form the most hygroscopic combinations. If the relative humidity is sufficiently high it also occurs at the exposed faces of any single component hygroscopic under those conditions. Consequently rate of absorption is approximtely proportional to the soluble salt content--double strengths absorb moisture faster than single strengths, high potash or nitrogen mixtures faster than low potash or low nitrogen mixtures. Phosphate content has the opposite effect, being the most non-hygroscopic component present, an increase in the P_2O_5 decreases rate of absorption.

As is demonstrated in the subsequent section, the moisture absorption rate pattern over 24 or 48 hours appears to be a much more valuable indication of practical industrial behavior than a knowledge of the critical hygroscopicity value or ultimate absorption limits.

Effect of Hygroscopicity

It is quite possible to have two mixtures of the same critical hygroscopicity value and same rate of absorption yet have entirely different appearance and flowing characteristics after the absorption of 3% or 4% moisture. This results from (1) the mutual solubilities of the salts present which control the volume of saturated solution and (2) particle sizes.

Insufficient emphasis has been placed in the past upon the fact that a fertilizer mixture is wetted not by water but by the aqueous saturated solution of all soluble salts therein. The volume of this saturated solution may be far different with equal moisture content in different mixtures, consequently the moisture content figure obtained by analysis may be of little value in indicating the apparent wetness. Conversely, the absorption of say three per cent moisture might cause one mixture to appear far wetter than another due to the volume of absorbed water being increased by highly soluble salts therein.

It is common knowledge that the average particle size has much to do with the effect of moisture upon flowing characteristics of dry mixtures. Damp coarse granules may contain 5% moisture and yet flow better than the same material in a pulverized state with but 2% moisture.

No doubt the foregoing discussion has left the impression that the hygroscopicity behavior of mixed fertilizers is a very involved process, and so it is. No single feature can be isolated and called the controlling factor--the critical hygroscopicity value, influenced by the specific mutual salt effect and extent of contact between components; the rate dependent upon conditions of exposure with reference to the critical value and especially upon the composition, degree of contact and protective effect of inert ingredients; and finally the capacity of a mixture to take moisture without losing its desirable characteristics--these all interlock to create exception to practically any classification or general theories attempted. Therefore, the following method is offered as an empirical, but simple and practical approach toward better understanding of hygroscopicity behavior.

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Apparatus and Method

The apparatus, shown diagrammatically in Figure 1 consists essentially of a series of Jolly spring balances from which the samples are suspended in an atmosphere of controlled humidity. The elongation of the springs is directly proportional to the moisture absorbed and readings can be taken at any time quickly and with no interruption in exposure conditions.

A box of 1/8" sheet aluminum was constructed approximately 4" x 10" x 36", the entire front of which was a tight fitting glass door swinging at the top by a long hinge (H). Humidified air, whose relative humidity was controlled by the concentration of sulfuric acid in the gallon bottle (S), was circulated by the small rotary pump (P) through the glass wool spray trap (T) and into the box by way of the perforated pipe manifold (M). It passed through the length of the box, was removed by a similar perforated pipe and returned to the pump passing by the dry and wet bulb thermometers (T_1)(T_2) on its way. An air volume of approximately one cubic foot per minute was circulated, which completely changed the air in the sample box every minute. This corresponds to an air velocity of nearly four feet per minute over the samples.

The fertilizer samples of 3 grams each were weighed directly onto the small aluminum pans, the springs having been calibrated to a zero point with a 3 gram load. These pans were suspended from the bottom of the Jolly balance springs (B) by small brass rods extending up through close fitting, knife edged holes in the top of the box. At the top of each pan support were soldered small wire pointers bent to travel close to the graph paper scale fastened on the rear wall of the box.

The entire apparatus was housed in a constant temperature room at 30°C. (86°F.) which was necessary to avoid thermal expansion errors in the Jolly balances as well as to maintain accurate relative humidity control. Although differing slightly from one to another, an elongation of one millimeter was equivalent to 20 milligrams (0.7% on a 3 gm. sample).

Duplicability of results were obtained by (1) maintaining close titration control on the sulfuric acid and using a large volume of acid (1 gallon), (2) frequent readings of the wet bulb thermometer and (3) inclusion of a standard sample on one pan in every run. Probably the largest source of error is in obtaining satisfactory 3 gm. samples of the usual commercial fertilizer mixtures. No grinding or screening was done on the samples as this would have exposed fresh surfaces not present in the original sample. However, the standard mixed fertilizer sample records and experience with many duplicate runs indicates normal reproducibility within $\pm$10% of the moisture absorbed, i.e. $\pm$1% differences up to 10% absorption, $\pm$2% differences in the 15%-25% region, etc.

An interesting feature of this apparatus is its adaptability to investigations of any moisture or solvent changes in samples exposed to controlled atmospheric conditions. Liquids could be handled by replacing the pans with cups; cellulose films, textiles and fibers could be suspended by hooks. The possibility of

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obtaining an hourly record of behavior without repeated weighings or alteration of exposure conditions makes this method more attractive than the familiar desiccator procedure. Equilibrium is achieved so much more quickly that results can be obtained within 24 hours at any single humidity. And as previously mentioned, the absorption rate pattern obtained appears to be more valuable than a single final equilibrium value after long exposure.

The kind of data obtained by this method and value of such information for behavior predictions are illustrated by the following selected samples.

Influence of Mixing Methods Upon Moisture Absorption Rate

In order to demonstrate the several effects discussed, it was found necessary to choose a double strength (8-16-14) mixture, since the differences exhibited by a single strength (6-8-4) were not significant. The blanketing effect of a filler and low concentration of active components in the normal grades reduced the intensity of variation quite materially. Four samples were selected as typical of the four major types of mixing: (1) ammoniated mix direct to final formula, (2) ammoniated superphosphate base mixed to formula after curing, (3) dry mix direct to final formula using lime or cyanamid and (4) dry based superphosphate mixed to formula after curing.

Mixtures (1) and (2) were ammoniated with 155 lbs. "Urea-Ammonia Liquor-B", one of the common ammoniating liquors carrying 45.3% total nitrogen of which 20.2% is in the form of urea and 25.1% is free or uncombined ammonia. All four samples contained 96 lbs. "Uramon", a commercial fertilizer compound containing 42% urea nitrogen.

Figure 2 shows the moisture absorption rate patterns at 60% relative humidity and 30°C. The four points at the left margin are the final equilibrium moisture gains after 10 days' exposure at 60% relative humidity and 30°C in a desiccator.

Especially significant are the different paths by which these equilibrium values were reached. The direct ammoniated mixture (A), wherein the greatest degree of mutual contact between soluble components exists due to warm moist condition of the freshly made goods, showed most rapid and uninterrupted absorption, reaching equilibrium in 24 hours. The ammoniated base (C) which was cured and cooled prior to contact with the soluble salts started a little more slowly, but as it was of the same moisture content establishment of mutual contact was soon accomplished and the absorption rate was parallel to the direct mixture after about six hours. The dry mixtures (B) and (D) showed a much greater delay in moisture absorption after a small initial gain. This delay of approximately 12 hours is attributed to the inability of the small amount of initial moisture absorbed to effect intimate contact between components except by slow capillary diffusion. When such mutual contact is once established the rate of absorption is again parallel to the direct ammoniated mixture.

In the case of single strength formulas which constitute a far greater commercial tonnage no significant differences were found. A direct ammoniated

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6-8-4 grade containing two units of urea nitrogen behaved practically identically with a similar dry based 6-8-4. This is due no doubt to higher initial moisture content in most normal strength goods promoting contact between components and also the presence of such large proportions of inerts. It has been concluded from the behavior of many test series that methods of mixing have little to do with ultimate hygroscopicity in the average fertilizer mixture.

Moisture Absorption Rates as Affected by Relative Humidities

The behavior of the dry based mixture at 60, 65, 70 and 75 per cent relative humidities is shown in Figure 3. The rate of absorption by this 8-16-14 mix is practically doubled by each 5% rise in relative humidity. The general nature of this relationship has not been established as yet.

Chiefly interesting is the disappearance of the delayed absorption, i.e. flat portion of the curves at higher humidities. This is a result of both a faster initial absorption wetting the mixture more quickly and the critical hygroscopicity of individual components having been exceeded.

Concentration of Active Components

In addition to the influence of mixing methods and moisture content upon contact between active components, their quantities must also be of importance. The grade of the fertilizer which is related to concentration of soluble salt has considerable effect upon moisture gain as shown by Figure 4. Considering nitrogen and potash compounds as the active components, the 8-16-14 grade contains 22% and the 6-8-4 but 10%; a difference which is reflected by their moisture gains being in practically the same ratio. This further demonstrates why mixing methods, moisture content, etc. do not show differences in 6-8-4 or lower grades.

Even though the total salt content may not change materially, an increase in any single active component will increase rate of moisture gain in direct proportion at relative humidities above its critical value. This relationship is shown in Figure 5, wherein the ammonium sulfate of a 6-8-4 mixture was replaced by increasing amounts of the three nitrogen compounds indicated (sodium nitrate, ammonium nitrate-calcium carbonate and urea) and samples exposed to 75% relative humidity. It is evident from this comparative picture that several of the common fertilizer salts furnish excellent examples of the direct relationship between moisture absorption and concentration.

Summary and Practical Conclusions

It can be seen from the foregoing discussion that hygroscopicity control in mixed fertilizers is primarily a matter of reducing contact between the components. Once contacts are established, the occurrence, rate and effects of moisture absorption depend upon: (1) the specific nature of ingredients, controlling both the critical hygroscopicity and ultimate condition of the mixture, (2) the number of hygroscopic points per unit area exposed, i.e. grade and concentration of specifically active components, (3) the relative humidity of the atmosphere and length of time which the sample is exposed.

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Inasmuch as the larger part of commercial fertilizers contain sufficient moisture and are so handled that little control can be exercised over degree of contact between hygroscopically active ingredients, practical considerations limit regulation of hygroscopicity to control of the active component in any given case. Furthermore, since rate of moisture absorption is proportional to concentration of active materials as shown in Figure 5 and the usability of a mixture depends not upon the actual moisture content but upon the capacity of the mix to absorb water and yet remain drillable, it follows that the limitation upon amounts of specific ingredients will vary with the particular formula, physical characteristics of the starting materials, and condition of exposure (climatic and bagging methods).

It is therefore practically impossible to set up arbitrary standards for use of such materials as urea, nitrate of soda, Calnitro, etc. However, correlation of data obtained by the apparatus just described with trade experiences in dozens of cases over the past two years or more have given reasonable assurance to a few general conclusions as to the use of hygroscopic components, such as urea, nitrate of soda, etc. in average fertilizer mixtures.

(1) Up to 1 unit of nitrogen from an active material may be incorporated in practically any mixture which meets the ordinary requirements for good practice --i.e. well neutralized phosphates, average moisture content and particle size-- with no significant effect upon drillability or feel.

(2) Around 2 units of nitrogen can be used in many cases but somewhat more attention must be given to specific effects in these. With this amount of urea, for example, the use of crude potash salts containing much sodium chloride, nitrate compounds, or high potash content (above 6%) as potassium chloride may lead to excessive moisture absorption. Many times the adverse effect of a particular salt pair, such as urea and nitrates, can be offset by changing the source of potash from muriate to sulfate--the latter being especially non-hygroscopic in combination with urea.

(3) Specific formulas containing large amounts of an active material can be developed which remain hygroscopically inactive for long periods and are commercially feasible in certain territories where suitable raw materials are available and marketing practices satisfactory.

The formulation of mixed fertilizers will perhaps remain an empirical matter insofar as control of hygroscopicity and drillability is concerned for several years to come. It is hoped, however, that the moisture absorption rate patterns as obtained by the method here presented will be of immediate practical use in comparative evaluations and possibly lead to better understanding of the fundamental principles.

"Uramon" is a trade-mark registered in the U. S. Patent Office by E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. - Editor.

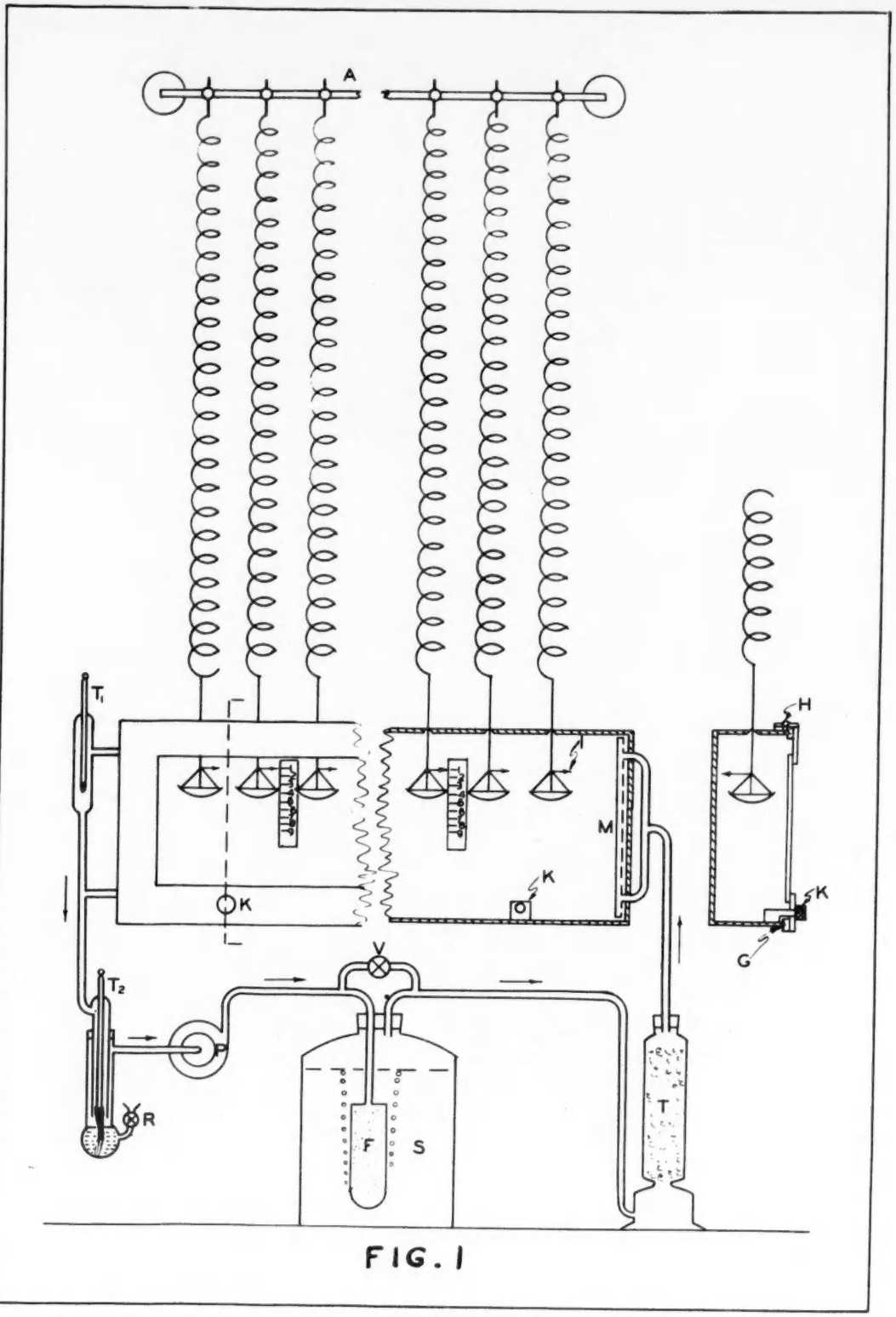


FIG. 1

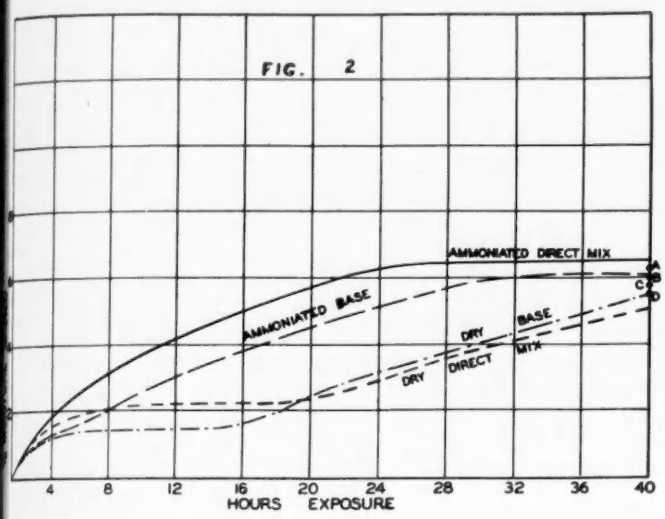


FIG. 2
AMMONIATED DIRECT MIX
AMMONIATED BASE
DRY BASE MIX
DRY DIRECT MIX
4 8 12 16 20 24 28 32 36 40
HOURS EXPOSURE

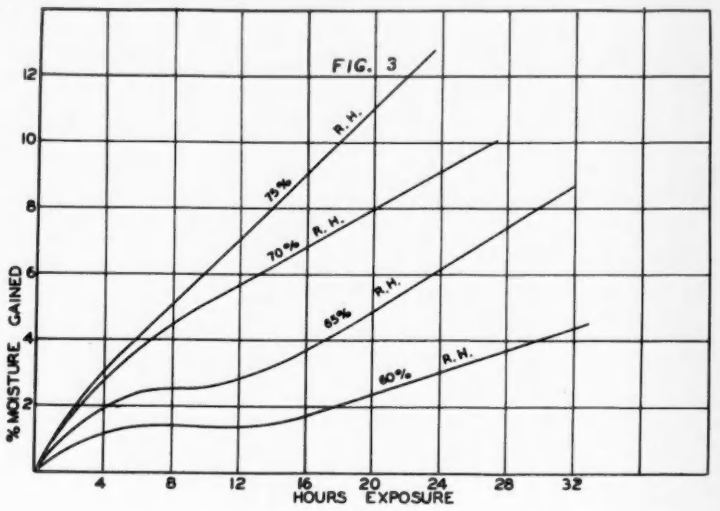


FIG. 3
% MOISTURE GAINED
75% R.H.
70% R.H.
65% R.H.
60% R.H.
2 4 6 8 10 12
4 8 12 16 20 24 28 32
HOURS EXPOSURE

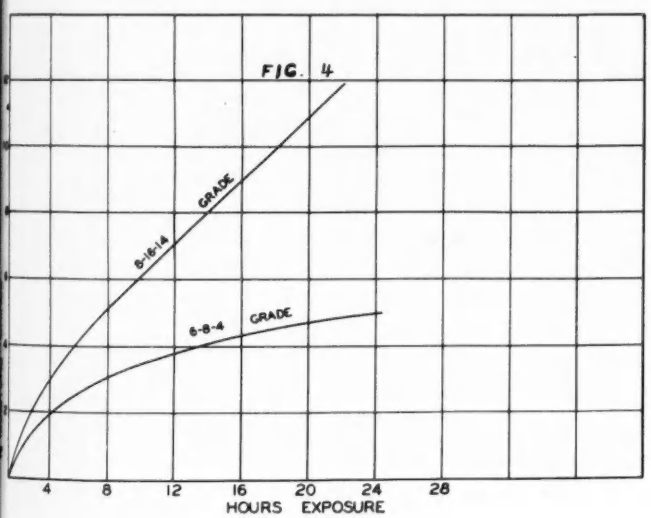


FIG. 4
8-16-14 GRADE
6-8-4 GRADE
4 8 12 16 20 24 28
HOURS EXPOSURE

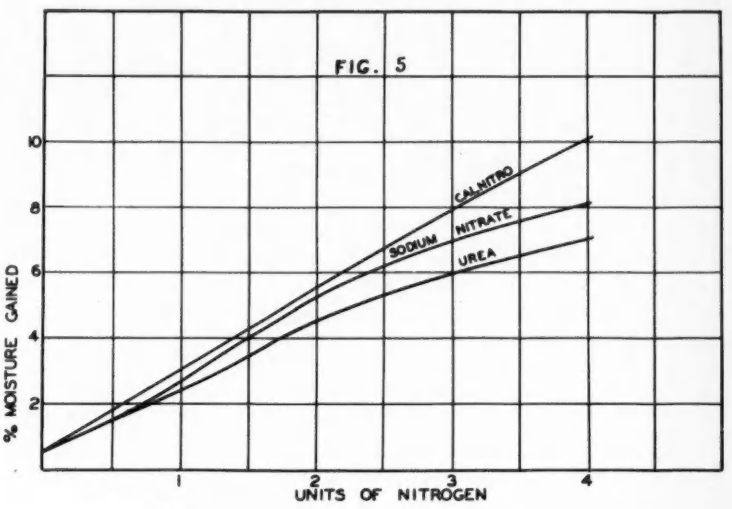
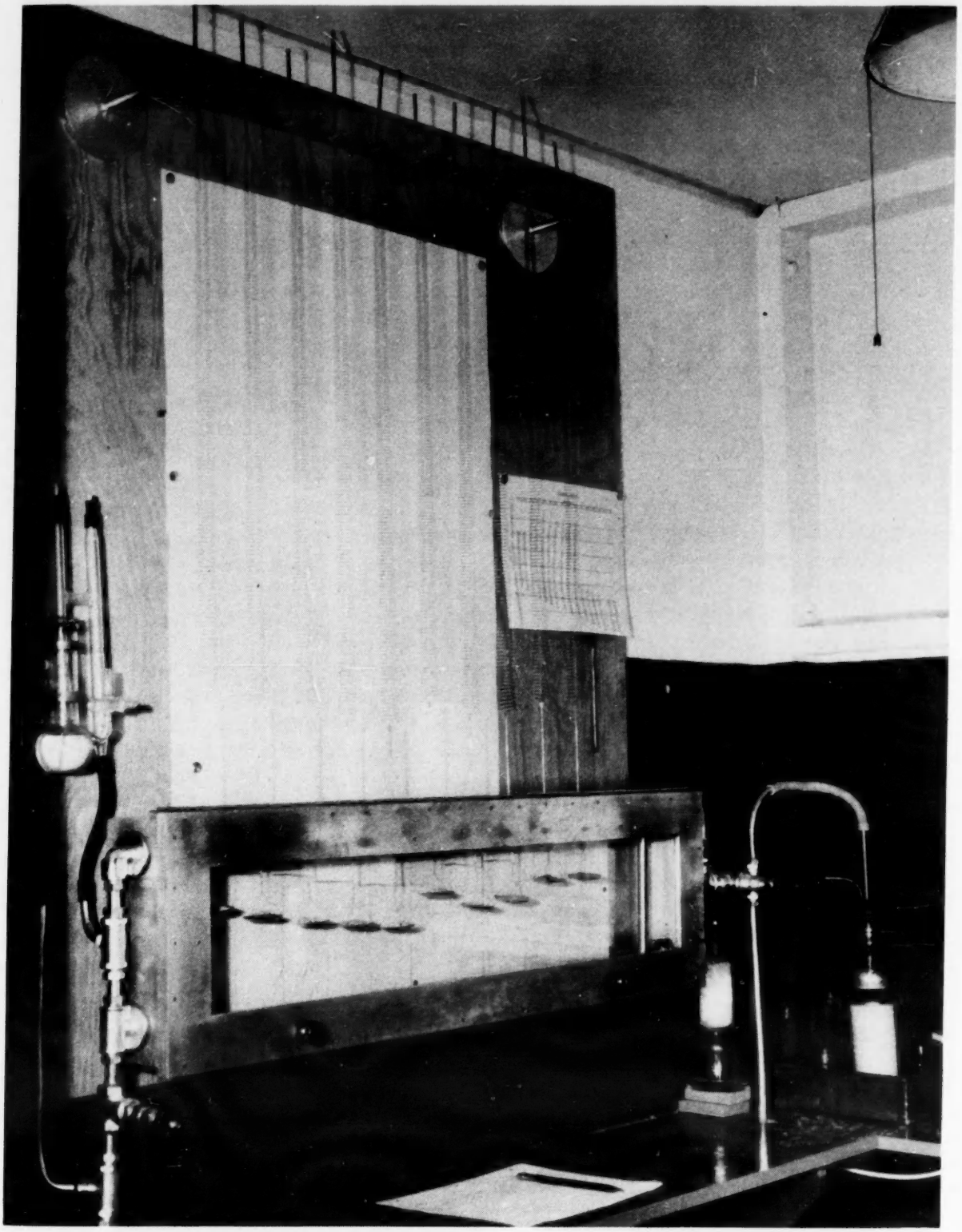


FIG. 5
% MOISTURE GAINED
CALNITRO
SODIUM NITRATE
UREA
2 4 6 8 10
1 2 3 4
UNITS OF NITROGEN



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FORMALDEHYDE USED IN STERILIZING WASH TO PREVENT DEVELOPMENT OF LATE BLIGHT ROT OF PICKED TOMATOES

EDITOR'S NOTE:- The information on late blight rot of tomatoes and its control, given here, is taken from "Market Diseases of Fruits and Vegetables: Tomatoes, Peppers, Eggplants," Miscellaneous Publication No. 121, United States Department of Agriculture.

Late blight rot is similar to late blight in potatoes and apparently is induced by the same fungus. It has been reported from a number of States, but is generally not of economic importance except in California, Virginia, West Virginia, and Pennsylvania. Shipments received from Mexico have also shown this disease. Late blight is often found in tomatoes planted in close proximity to potato fields, or in crops following potatoes, but this association is not always necessary. When susceptible crops are grown, such as the potato and tomato, in regions whose temperature and moisture conditions are favorable to the growth and spread of this fungus, late blight is one of the most destructive diseases known. In many instances the whole crop is lost, and in mild epiphytotics of this disease it is not unusual for 20 to 50 per cent of the fruits to show decay by the time they reach the market.

All of the aboveground parts of the tomato plant are susceptible to attack by the late-blight fungus. Large water-soaked greenish-brown to black blotches are produced on the leaves and frequently on the stems. During wet weather a fine white downy mildew is formed on the under surfaces of affected leaves, as well as on the stem lesions. In severe epiphytotics of this disease the vines are completely killed within a few days and the field appears as if a heavy frost had occurred.

Attacks Fruits at All Stages of Growth

Tomato fruits are apparently susceptible to attack by this fungus during all stages of their development. Small tomatoes less than 1 inch in diameter often become completely decayed while hanging on the vine, and fruits of larger size showing all stages of decay are readily found in the field during epiphytotics of the disease. In practically all instances the decay starts at the stem scar and progresses down through the tissues, producing a watery brown breakdown of the internal as well as the external tissues. The first visible symptom of decay on the fruit is a small greenish-brown blotch less than one-fourth inch in diameter at the edge of the stem scar. Pressure applied by moving the thumb over the botch toward the scar causes drops of water to come out at the edge of the scar. As the decay progresses the tissues become more water-soaked and there is a change from greenish brown to brown without any definite markings

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and generally without visible evidence of the fungus. If the decay is well advanced and the fruits are in a moist, well-protected place, the fungus develops on the surface of the decaying tissues and is in evidence as a fine white mildew.

Lesions that develop during transit under the humid conditions within the car and under the protection of the wrappers generally show as large greenish-brown water-soaked blotches with a fine white mildew especially prominent over the stem scar.

Causal Factors

The amount of damage caused by late blight is directly related to the weather conditions. When temperature and moisture are favorable for the development of the inciting organism, Phytophthora infestans, it is one of the most destructive fungi known. Most serious losses are sustained during wet seasons when the nights are cool (50° to 60°F.) and the days moderately warm (60° to 75°).

A mean daily temperature above 75° checks the disease. The spores of the fungus are killed within a few days during dry weather when the temperature reaches 80°. Consequently, in regions where the temperature is high and the air is dry for the greater part of the time, late blight is not an important disease. It is more prevalent in regions of high altitude, such as the mountainous sections of Virginia and West Virginia, and in coastal regions, such as southern California, where fogs and rains are frequent.

During periods in which there is an abundance of atmospheric moisture to favor spore production and germination, the tomatoes harvested from fields showing any appreciable amount of late blight are generally subject to a great amount of decay in transit, even though they show no evidence of disease at the shipping point. The fungus usually enters the tomatoes through the stem scar, but it may enter through a wound on any part of the fruit. After infection has occurred about five days are required for the decay to become visible. Shipping tests have shown that even the most carefully selected tomatoes from blighted fields may show over 8 per cent decay at the end of a 6-day transit period, and that tomatoes commercially graded and packed from similar fields may show as high as 32 per cent of decay on arrival at the receiving market. Tomatoes in which there was no visible evidence of decay when packed often develop spots varying from one-half to 1-1/2 inches in diameter during a 6-day transit period. Visible spots present on fruits at the shipping point generally increase over an inch in diameter within six days, the average transit period from California fields to mid-western markets. Test shipments indicate that there is but little spread of the disease from decaying to healthy fruits during transit. Such new spots as have been observed to develop by contact during transit were mainly at the stem end of the tomatoes and were about 2 inches in diameter.

Control

Late blight may be kept under control in the fields if the weather permits a thorough spray program to be followed. Best results are generally obtained by use of Bordeaux mixture or some of the copper dusts.

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Tomatoes from fields showing an appreciable amount of leaf and stem blight should not be shipped until after they have been held for a few days to allow for development of decay and for subsequent sorting and grading. The amount of decay developing during transit and marketing in stock harvested from blighted fields may be greatly reduced by immersing the tomatoes for two minutes in a sterilizing wash (1 part commercial formaldehyde to 300 parts of water) and then allowing them to stand for four or five days before sorting and packing for shipment.

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SETTLING BASINS FOUND USEFUL FOR PREVENTING SILT FILLING WATER STORAGE PONDS AND WATER HOLES ON FARMS AND RANCHES

EDITOR'S NOTE:- Announcement of an effective method of preventing the rapid filling of earth water reservoirs with sediment should be of considerable interest to agricultural engineers, stockmen and farmers. The fact that the settling pond can be cleaned out by blasting with dynamite helps make this method thoroughly practical.

By L. F. Livingston, Manager,
Agricultural Extension Division,
E. I. du Pont de Nemours & Co., Inc.,
Wilmington, Delaware.

Obviously, water is a primary necessity for any farming operation. Its maximum control is essential in the so-called dry farming regions of the country; regions wherein the rainfall is scattered and the total inches of rainfall are barely enough to support growing crops. The lack of control in the past has been responsible in part for drouth conditions, and certainly has been responsible for the "Dustbowl" situation.

A great deal of very successful work has been done by the Soil Conservation Service in working out methods of controlling and holding rain and snow water on farms; the basin lister is a very fine example of this. This machine deep plows the field and leaves it with a series of small basins or ponds some 2 ft. wide and 20 to 50 ft. long. These ponds have proved very useful in stopping fast runoff which has been the greatest drawback to increasing soil moisture. Along with this has been the making of innumerable ponds or small lakes for the storage of water primarily for animal consumption, fire protection, garden irrigation and general farmstead use. The Soil Conservation Service reports a great increase in the number of such storage ponds or water holes all over the Middle West. The use of such ponds has been common in Texas and Oklahoma regions for many years.

Silt Deposits Reduce Capacity of Ponds

One of the greatest problems has been the cleaning of these ponds. The runoff water which fills the ponds invariably deposits a considerable percentage of silt. Reports have come from Texas stating that a pond usually fills up with silt at the rate of 2 ft. every three (3) years; thus a 6 ft. pond in 3 years would lose 1/3 of its capacity. Ponds are usually located in a slight valley where they will catch the runoff from a certain area. We have often been asked to clean out ponds with dynamite. While ponds as great as 50 ft. in width have

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been successfully cleaned out, with dynamite, it is a rather difficult blasting procedure which requires considerable experience. On the other hand, dynamite placed in one or two rows of holes will very readily and economically clean a pond 20 ft. wide, but a great many ponds that now exist and are planned, will be 150 ft. wide by 200 to 300 ft. long.

Settling Basin Retards Silt Deposit

An ingenious method of handling the silt problem has been worked out by the making of a settling basin some 20 ft. wide and 100 ft. long above the storage pond. Silt laden water must pass through the settling basin before it goes into the storage pond, and a protected overflow from the settling basin must be provided for this purpose. The water loses a large percentage of the silt so that a minimum lodges in the storage pond. The settling basin should be 6 or 7 ft. deep because it will fill up 2 to 4 ft. each year. Because it is long and narrow it can be readily and economically cleaned out in the same manner a large drainage ditch is cleaned with dynamite. This type of program greatly simplifies one of the meanest jobs the pond owner has in cleaning the pond. The annual cleaning of the settling basin may evolve any one of several types of loading methods, all of which have been explained in previous issues of Agricultural News Letter.

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MOSQUITO CONTROL AS IT AFFECTS WILDLIFE CONSERVATION STUDIED BY THE BIOLOGICAL SURVEY AND OTHER AGENCIES

EDITOR'S NOTE:- In this article Dr. Gabrielson points the way to cooperative efforts which can contribute to the control of mosquitoes and also insure the preservation of natural environment for valuable wildlife.

By Ira N. Gabrielson, Chief,
Bureau of Biological Survey,
Washington, D. C.

There is reason to hope that the troublesome mosquito may be disposed of without destroying valuable wildlife in the process.

Wildlife conservationists are studying the mosquito control problem in an effort to find methods to eradicate the pests without at the same time eradicating valuable species of bird and animal life which inhabit the coastal marshes. These marshes in a natural state form an environment wonderfully productive of shorebirds, waterfowl, and furbearing animals like the muskrat, but they also breed myriads of mosquitoes. Draining the water from the pools and sloughs disposes of the mosquito, at least for a time, but it also impairs the usefulness of the area for valuable wildlife. In many instances this damage may be irreparable because of the destruction of vegetation and animal organisms which furnish cover and food for wildlife.

Drainage is an expensive method and to remain effective in controlling mosquitoes the ditches must be kept in constant repair year after year. Without regular attention ditch walls crumble, vegetation chokes up the channels, and the ditches degenerate into series of stagnant pools ideal for mosquito production but valueless for any other purpose.

Drainage Necessary on Some Areas

It is to be expected that in spite of these disadvantages drainage will be found the only practical method of mosquito control on some areas but the work will be correlated with wildlife conservation and handled in ways to reduce or eliminate damage to the birds and animals. Under this arrangement between the public health officials and the specialists of the Biological Survey, mosquito breeding areas have been treated successfully by ditches that lead to permanent pools or reservoirs which afford breeding places for fish and other natural enemies of the insect. A suitable constant water level is maintained for wildlife in the marshes at all times through the use of appropriate control structures, such as tide gates and weir boards. Where important wildlife values are involved and where such biological aides are not applicable, larvicides, innocuous to important plant and animal life, are substituted for non-volatile oils as a method of control.

Agricultural News Letter (du Pont)
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THE INSECT MENACE AND THE ROLE OF CHEMISTRY IN COMBATING IT DISCUSSED BY AN AUTHORITY

EDITOR'S NOTE- This is the second part of an informative paper presented before the 1937 meeting of the Association of Official Agricultural Chemists by Dr. McDonnell, President of the organization. The first part of the paper was printed in the October number of this publication.

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I shall not attempt to review the entire history of insecticide development, but merely point out a few of the more outstanding achievements. In 1892 lead arsenate came prominently before the public as an insecticide for the gypsy moth, against which it is particularly effective. In a short time it largely replaced Paris green as an insecticide for plants, and for many years it has been used more extensively than any other arsenical for orchard pests. For the past ten years the amount used annually has averaged about 30,000,000 pounds.

At about the time the gypsy moth started to attract serious attention, another destructive insect, the cotton boll weevil, made its appearance in Texas. Gradually it extended its area of infestation until now it covers practically the entire cotton-growing districts. As a result of a study of methods for the control of this insect calcium arsenate was developed about 1920 and was found to be the most effective insecticide for use on cotton. Its use increased rapidly, and at the present time the annual consumption approximates that of lead arsenate. The only other arsenical compound that is used extensively as an insecticide is white arsenic. Owing to its caustic qualities it cannot be used on foliage, but it is used in large quantities in poisoned baits for the killing of grasshoppers and in the form of an alkaline solution for the dipping of cattle to eradicate cattle ticks. Two to three thousand tons are used annually for these purposes. It is thus seen that arsenical preparations for the control of insects are used in excess of one-half of a pound every year for each man, woman, and child in the United States. This large quantity, much of which is applied to our fruits and vegetables, is causing much concern, and rightly so, to our food chemists, health authorities, and the general public. In addition to the arsenicals, the other poisons of various kinds used on our crops and animals and in our homes amount to many millions of pounds annually.

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Insecticide Industry Undergoing Change

At present inorganic materials dominate the market, but owing to the health hazard involved from the presence of toxic residues on sprayed fruits and vegetables and the restrictions being placed upon the marketing of these products by food control and public health officials the insecticide industry is undergoing a marked change. Extensive research work is being done by the Federal and State Governments and other agencies to develop insecticides that will minimize this health problem. The substitution of synthetic organic compounds offers the most promise. Some progress has been made in this field, but its possibilities are limitless. The principal compounds of this character used at the present time are naphthalene, paradichlorobenzene, certain aliphatic thiocyanates, chloropicrin, and more recently ethylene oxide and ethylene dichloride. The two compounds last mentioned, mixed with carbon dioxide, are now being used on a large scale for the destruction of insect pests in food products, stored grain in elevators, and for the fumigation of flour and feed mills. They are also replacing to a large extent the highly inflammable and explosive carbon disulfide, which has been used extensively for these purposes for many years, and hydrocyanic acid gas, which is so toxic to man.

Uses of Rotenone and Pyrethrum

The most recent development in the field of new products is the use of rotenone-bearing plant material and extractives, which are highly toxic to many forms of insect life attacking plants and animals and those occurring in the home. Rotenone is a constituent of many plants of the Leguminosae family and at present the principal commercial sources are Derris elliptica (usually referred to merely as "derris") and Lonchocarpus nicou (known commercially as "cubé"), which are imported from the British and Dutch East Indies and the northern parts of South America. It has been known for many years that the roots of these plants contain ingredients highly toxic to insects and some other forms of animal life, but it is only during the past five years that their commercial use for insect control has reached large proportions. There are now scores of commercial insecticides on the market that owe their activity to these materials or extracts made from them. In 1936 this country imported more than two and one-half million pounds of derris and cubé in the form of unground and powdered roots. The importations for 1937 will greatly exceed this figure.

Another plant material that is used extensively for insecticidal purposes is pyrethrum or insect powder, which consists of the powdered flower heads of certain species of chrysanthemum. While the toxicity of pyrethrum to insects was known more than one hundred years ago, its use as an insecticide has increased tremendously in recent years. We now import approximately 13,000,000 pounds annually, the greater part of which comes from Japan. Experiments are being carried on by the United States Department of Agriculture and some of the State Experiment Stations to determine whether or not it can be grown profitably in this country.

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War Against Insects is World-Wide

The war against the insects has become a world-wide movement. People are beginning to realize that an adequate supply of food, both vegetable and animal, would be impossible without the use of insecticides and fungicides. In this fight our Federal Government employs hundreds of scientists and trained men, who are devoting their lives to this work, and numerous field laboratories are maintained throughout the country. Every state has its corps of expert workers and investigators. Some of our large cities maintain city entomologists, and California has its county entomologists. Practically all of our agricultural colleges and universities, as well as the medical schools, are training men in insect biology; a number of our large manufacturers and oil companies, as well as endowed non-profit institutions, maintain research laboratories manned by trained experts, where extensive research on methods of control of insects and the development of new insecticides are being conducted. Among the latter organizations may be mentioned The Mellon Institute of the University of Pittsburgh. It was established in 1913 for the purpose of providing a means for a manufacturer, or association of manufacturers, to investigate new materials and processes in chemistry and allied subjects. Practically from the beginning of its foundation it has conducted, through grants from manufacturers, researches on insecticides. A similar organization, although somewhat more limited in scope, is The Crop Protection Institute, which was organized in 1920 under the auspices of the National Research Council. At that time manufacturers of insecticides were producing the standard materials, such as lead and calcium arsenates, Paris green, and lime sulfur solution, but practically none of them employed experts in the biological sciences or possessed research departments for the investigation of pest control problems. The Institute was established for the purpose of providing an agency that could make thorough and impartial tests of insecticides and fungicides for manufacturers and commercial firms that desired to improve their products or develop new ones to meet the needs of farmers for controlling crop pests.

Various Agencies Doing Research

The Boyce Thompson Institute for Plant Research, Inc., 1086 North Broadway, Yonkers, New York, officially opened in 1924, conducts "fundamental research on practical plant problems," including work on insecticides.

The National Association of Insecticide and Disinfectant Manufacturers has recently established a fellowship at the Ohio State University to study and develop laboratory methods for evaluating insecticides for use against household insects.

Probably the most extensive researches conducted by a single manufacturer for the purpose of developing new and more effective insecticides and fungicides for agricultural use are those of the du Pont Company of Delaware. The researches of this company are directed especially toward a study of the insecticidal and fungicidal properties of synthetic organic compounds. Among other manufacturers actively engaged in research work in this field may be mentioned Rohm & Haas Co., Philadelphia, Pa.; McCormick & Co., Baltimore, Md.; California Spray Chemical Corporation, Berkeley, Calif.; American Cyanamid & Chemical

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Corporation, New York, N. Y.; and several of the larger oil companies and chemical manufacturers.

In addition to the agencies mentioned, there are in the United States many entomologists engaged in private practice as consultants, and in practically all of the larger cities professional so-called "exterminators" are engaged exclusively in contract work to free buildings of insect pests. In New York City alone, according to a survey made by the American Institute of Health, an army of 400 such men is continuously so employed. This number does not include employees of hotels, apartment houses, stores, restaurants, and food warehouses who are occupied full or part time in combating insect infestations.

Marketing Controlled by Many Laws

Many laws have been passed to control the marketing of commercial insecticides. The first such law in this country was passed by the General Assembly of Louisiana in 1890, and the second by New York in 1898. Both of these laws applied only to Paris green, which at that time was the most important agricultural insecticide. As the insecticide industry increased it soon became apparent that a Federal law was needed. The numerous reports by growers of damage to crops and fruit trees through the use of improperly made material and the unsatisfactory state of the industry at that time made it imperative that some action be taken to win the confidence of the public in these articles of trade. After considerable agitation and many conferences among those interested in the subject and hearings before Congressional committees a law was introduced, which was passed in 1910 and became effective January 1, 1911. To the Association of Economic Entomologists belongs most of the credit for the procurement of this legislation, although it had the backing of the leading insecticide and fungicide manufacturers of the country and as a regulatory law stands out as unique in this respect. No regulatory law that has been passed by Congress more nearly affects the welfare of every individual of the nation.

At the time of the passage of this Act the insecticide industry was in a very unsatisfactory condition. Most manufacturers knew little regarding methods of control of insects and fungous diseases, and much of the material on the market was improperly manufactured and ineffective for the purpose for which it was recommended. Competition was such that scrupulous manufacturers were not able to meet it without lowering the quality of their products. The passage of this law marked the beginning of a great change in the insecticide industry,-its growth has been phenomenal and there is little resemblance between the insecticidal products on the market to-day and those on the market at the time of its passage. Other factors have, of course, aided in bringing about the increased use of insecticides. As a result of researches by entomologists and others, great progress has been made in methods for the control of insects, new products have been developed, and better methods of application devised.

For the most part the trade is in sympathy with the Federal law since it tends to keep down unfair competition and to instil greater confidence in the buyer for the products subject to its provisions. Laws applying to insecticides have been passed by about one-half of the states. Most of these are similar in their requirements to the Federal statute, but few of them are being vigorously enforced due, primarily, to a lack of the necessary funds.

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Plant Quarantine Contributes to Pest Control

In addition to laws regulating the marketing of insecticides, plant quarantine laws have been enacted for the purpose of preventing the introduction of plant pests into this country and limiting their spread after they have reached here. The first law of this character enacted in this country was passed by the State Legislature of California in 1881. It was not, however, until 1912 that a national law, the Federal Plant Quarantine Law, was enacted by the United States Congress. This act regulates the importation into, as well as the movement between the states, of all plants and plant products that may carry plant diseases and insect pests. Its enforcement has been of inestimable benefit in preventing or retarding the spread of destructive insect pests in this country.

We are still behind some countries in legislation designed to control the ravages of insects. Germany, for example, enacted a law in March of this year empowering the Government to compel farmers to apply insecticides and institute other officially prescribed practical measures for combating plant pests and disease. If necessary, the Government itself will do this work and require the farmer or establishment benefited to contribute to the cost of the service.

In considering this subject of insect control it would be amiss not to make reference to the valuable work of this Association in the development and adoption of methods of analysis of commercial insecticides, which have been of incalculable aid in connection with the enforcement of regulatory laws. This work was initiated by the Association in 1898 and has been continued without interruption since that time. Dr. A. L. Winton, who was President of the Association that year, made reference in his presidential address to the growing need for accurate methods of analysis of these products and recommended "that a referee on insecticides and fungicides be appointed each year to investigate methods for the determination of the valuable constituents of these products." Affirmative action was taken on this recommendation, and Dr. de Schweinitz, than a scientist in the Bureau of Animal Industry of the Department, was appointed referee for the following year,--the first referee of the Association on this subject. As a result of the work of members of this Association and collaborators since that time many accurate and valuable methods of analysis for these products have been developed and adopted by the Association. These methods, published in Methods of Analysis, A.O.A.C. and in Wiley's Principles and Practice of Agricultural Analysis, Vol. II, issued by this Association, constitute the most inclusive compilation of methods relating to insecticides and fungicides now in print.

Importance of Toxic Compounds in the Soil

The work of the Association, however, has not been completed. As pointed out by Dr. MacIntire in his Wiley's memorial address before this Association two years ago, "The marked increase in the necessary use of various insecticides has also injected new problems relating to the effects induced by their residues." One of these problems has already been referred to,--that of the health menace by reason of the residue left on the crop at harvest time. Another, which may become equally important, is the effect the accumulation of these toxic compounds

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in the soil may have on the growth of plants and the possible injury to man and animals from eating products grown on such soils. One of the leading fruit growing areas in the Pacific Northwest has received as much as 7,000,000 pounds of lead arsenate annually for the past twenty years, and it has already been shown that in some sections injury to vegetation through arsenic accumulation in the soil is manifest. The amount of calcium arsenate usually recommended to be used on cotton is from 15 to 20 pounds per acre annually, which over a 25-year period would average 450 pounds per acre. For the destruction of the grubs of the Japanese beetle in the soil it is being recommended that lead arsenate be worked into the soil at the rate of 10 pounds per 1000 square feet, or 430 pounds per acre. This treatment is said to be effective against the beetle grubs for about five years, when the application must be repeated. Nurserymen located in the Japanese beetle infested area who ship outside of the quarantine region are required by Government regulations to treat the soil on which they grow their nursery stock by certain specified methods in order to destroy the beetle grubs in the soil. One of these methods is to work lead arsenate into the soil at the rate of 1500 pounds per acre. Owing to the insolubility of lead arsenate its removal from the soil by leaching is very slow, and one would expect that such heavy applications would in time seriously injure the soil for cultivation purposes. Selenium compounds are now being used to some extent on crops for the control of certain insects, particularly red spiders, and, owing to the extremely toxic character of selenium to human beings and the fact that it is taken up from the soil by the growing plant, fear has been expressed that man and animals might be injured by eating products grown on such soils. Some investigational work on the absorption of selenium by plants has already been done by the Bureau of Chemistry and Soils.

Absorption of Gases is a Problem

The absorption of gases by fumigated food products is also a problem for the food control officials. Hydrocyanic acid is used extensively for fumigating a great variety of food products that are subject to insect infestation, such as fresh and dried fruits, vegetables, cereals and other edible products packed in cartons, such as flour, meal, nuts and nut meats, cheese, and candies. Investigation has shown that while hydrocyanic acid is usually dissipated quite readily from many of such fumigated products, in the case of some it is held for long periods of time.

In that part of this paper relating to methods for the control of insect pests I have stressed the use of insecticides. It is not intended, however, to belittle other control measures, such as biological, through the use of insect parasites; plant selection and breeding to produce resistant varieties; and cultural practices, in which some striking developments have been made, but the problem is essentially one of applied chemistry and one in which the chemist must play a leading part.

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DU PONT PLANT SITE DONATED FOR WILDLIFE USE

A tract of 1,118 acres of land near Ashburn in Pike County, Missouri, has been donated by E. I. du Pont de Nemours & Company to the Conservation Commission of Missouri for a wildlife restoration area, the company announced recently. The land surrounds the company's Ashburn plant, now abandoned, which formerly manufactured dynamite and commercial high explosives.

Under the deed "the land shall forever be used for a public demonstration area for a combined forest preserve and wildlife restoration and control project." It will bear the name "Du Pont Reservation." The tract, which fronts on the Mississippi River, will be suitable for raising quail and wild turkeys and the upland area for deer.

A new dam, which it is expected will be built by the Federal Government at this point on the Mississippi River, will back up water over the low area of the land forming an ideal resting area for migratory waterfowl.

The gift, it is hoped, will also be an additional inducement to hasten the establishment of the Mississippi River Parkway which is now being proposed. It is provided that part of the land may be transferred to the Federal Government for this purpose. Governor Lloyd C. Stark of Missouri and the Conservation Commission are now conferring with Secretary of the Interior Harold L. Ickes on the proposed highway which would follow the river from Minneapolis-St. Paul down to the Gulf of Mexico.

The du Pont Company is interested in a land restoration program because it feels that it is good business.

Following the passage in 1936 of Amendment No. 4 creating the Missouri Conservation Commission as a non-political body the du Pont Company became interested in the possibilities of conservation in Missouri, and has felt great confidence in the new commission. Because of the intelligent approach to the conservation problem made by the commission thus far, the company feels that a wise use will be made of the tract of land.

WHAT THE EXPERT KNOWS ABOUT TERMITES AND ROT

A twelve-page illustrated booklet describing an improved method for treating lumber to resist termites and rot, offering the most effective clean lumber treatment known to date, may be had by writing to the Public Relations Department, E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware. This booklet, entitled, "What The Expert Knows About The Building Bogies - Termites and Rot," discusses in non-technical language the practical angle of this subject, covering the exaggerated as well as the real loss due to termites, and the place of the new development, known as chromated zinc chloride, in combating termites and the more destructive force of dry rot.

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